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Art Unit	1763
Examiner Name	Rudy Zervigon
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ENCLOSURES ***(Check all that apply)***

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment/Reply
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  - ☐ Affidavits/declaration(s)
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PATENT
Attorney Docket No.: 1771X2T19930
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OIPE JC102
FEB 0 5 2004
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re application of:	Examiner: Rudy Zervigon
SEBASTIEN RAOUX et al.	Art Unit: 1763
Application No.: 08/988,246	APPELLANT'S BRIEF UNDER 37 CFR § 1.192
Filed: December 1, 1997	
For: METHOD AND APPARATUS FOR MONITORING AND ADJUSTING CHAMBER IMPEDANCE	

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Applicants, in the above-captioned patent application, appeal the final rejection of claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30. The claims on appeal have been finally rejected pursuant to MPEP § 706.07(b). Accordingly, this appeal is believed to be proper. This appeal brief is filed in triplicate.

I. REAL PARTY IN INTEREST:

The real party in interest for the above-identified application is APPLIED MATERIALS, INC., a Delaware corporation having its principal place of business at P.O. Box 450A, Santa Clara, California 95052. The assignment is recorded in the U.S. Patent and Trademark Office on December 1, 1997 at Reel 8897/Frame 0170.

II. RELATED APPEALS AND INTERFERENCES:

There are no appeals or interferences related to the present appeal.

III. STATUS OF CLAIMS:

Claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 are pending.

Claims 3, 4, 6, 11-14, 16, 19, 20, 24, 26, 28, and 29 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al. Claims 5, 27, and 30 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al.

Claim 23 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. and Patrick et al., and further in view of Yamagata et al.

Claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-5 of U.S. Patent No. 6,098,568 in view of Patrick et al.

Claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-6 of U.S. Patent No. 6,041,734 in view of Patrick et al.

IV. <u>STATUS OF AMENDMENTS:</u>

Claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 were rejected under 35 U.S.C. § 103(a) upon the grounds set forth in the Final Office Action mailed on July 24, 2003.

Applicants filed a Response under 37 C.F.R. § 1.116 on September 24, 2003. No amendments were made. An Advisory Action mailed November 3, 2003 indicated that the Response would not be entered. A terminal disclaimer was filed on January 9, 2004 to overcome the rejections under the judicially created doctrine of obviousness-type double patenting.

In accordance with 37 C.F.R. § 1.192(c)(9), a copy of the claims involved in the appeal are contained in the Appendix attached hereto.

V. <u>SUMMARY OF THE INVENTION:</u>

Embodiments of the present invention provide an apparatus for depositing CVD films on a substrate. The apparatus employs mixed frequency RF power and provides a gas distribution manifold for directing process gases into the chamber. The potential for arcing is greatly reduced by connecting the low frequency RF power source to a low frequency (LF) electrode embedded in the substrate holder and connecting the high frequency RF power source to the gas distribution manifold, which also functions as a high frequency (HF)

electrode. An impedance monitor comprises a first impedance probe electrically coupled to the high frequency electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to the low frequency electrode to measure the impedance at the LF electrode. An independent matching network decouples the low frequency waveform from the high frequency waveform to minimize phase interferences between the waveforms. These features combine to allow deposition processes to proceed at conditions that were unattainable in prior substrate processing chambers and also enable the substrate processing apparatus of the present invention to be usable in sub-0.35 μm deposition processes including 0.25 and 0.18 μm processes.

According to an embodiment of the present invention, a substrate processing system comprises a deposition chamber comprising a reaction zone and a substrate holder that positions a substrate in the reaction zone. The substrate holder comprises a low frequency (LF) electrode. A gas distribution system includes a gas inlet manifold for supplying one or more process gases to the reaction zone. The gas inlet manifold comprises a high frequency (HF) electrode. A plasma power source is provided for forming a plasma within the reaction zone of the deposition chamber, and comprises a high frequency power supply coupled with the HF electrode and a low frequency power supply coupled with the LF electrode. An impedance monitor comprises a first impedance probe electrically coupled to the high frequency electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to the low frequency electrode to measure the impedance at the LF electrode. A processor is coupled with the impedance monitor for adjusting processing conditions of the deposition chamber based on measurements by the first impedance probe and the second impedance probe.

In another embodiment of the invention, a variable capacitor is electrically coupled to the chamber and controllably coupled to the processor, wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. A matching network is electrically coupled to a high frequency RF generator and the gas manifold, wherein the matching network has capacitors that are different from the variable capacitor.

In another embodiment, a processor is communicatively coupled to the impedance monitor for receiving as an input a measured impedance level of the plasma. A variable capacitor is electrically coupled to the LF electrode and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. A matching network is coupled between a low frequency RF generator and the variable capacitor, wherein the matching network includes capacitors that are different from the variable capacitor.

VI. ISSUES:

The following issues are presented:

Whether claims 3, 4, 6, 11-14, 16, 19, 20, 24, 26, 28, and 29 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al.

Whether claims 5, 27, and 30 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al.

Whether claim 23 is properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. and Patrick et al., and further in view of Yamagata et al.

VII. GROUPING OF THE CLAIMS:

In the present case, the rejected claims do not all stand or fall together. Applicants submit that each claim presents distinct issues concerning patentability. In the interest of administrative economy and efficiency, however, Applicants agree to narrow the issues for the purposes of this appeal only by grouping the claims as follows:

Group 1: Claims 11, 3, and 6, which relate generally to a substrate processing system including a substrate holder which comprises a low frequency (LF) electrode, a gas inlet manifold which comprises a high frequency (HF) electrode, an impedance monitor comprising a first impedance probe electrically coupled to the HF electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to the LF electrode to measure the impedance at the LF electrode, and a processor coupled with the impedance

monitor for adjusting processing conditions of the deposition chamber based on measurements by the first impedance probe and the second impedance probe;

Group 2: Claims 4 and 12, which are directed generally to the same subject matter as claim 11, but which include the additional limitation that the processor adjusts a capacitance level of a variable capacitor electrically coupled to the chamber to vary the impedance of the plasma in response to an output of the impedance monitor;

Group 3: Claim 23, which is directed generally to the same subject matter as claim 4, but which includes the additional limitation that the variable capacitor is separate from an RF matching network electrically coupled to the chamber;

Group 4: Claim 5, which is directed generally to the same subject matter as claim 3, but which includes the additional limitation that the processor controls a pressure control system to vary the pressure within the chamber in response to the measured impedance level of the plasma;

Group 5: Claims 13, 14, and 19, which are directed generally to the same subject matter as claim 11, but which include the additional limitation that an impedance tuner is coupled in series to the substrate holder.

Group 6: Claim 29, which is directed generally to the same subject matter as claim 13, but which includes the additional limitation that the processor is configured to adjust a setting of the impedance tuner based on measurements by the first impedance probe and the second impedance probe;

Group 7: Claim 27, which is directed generally to the same subject matter as claim 11, but which includes the additional limitation that the processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe;

Group 8: Claim 28, which is directed generally to the same subject matter as claim 11, but which includes the additional limitation that the processor is configured to adjust at least one of a high frequency RF power level of the power source and a low frequency RF power level of the power source, based on measurements by the first impedance probe and the second impedance probe;

Group 9: Claim 16, which relates generally to a substrate processing system including a substrate holder which comprises a low frequency (LF) electrode, a gas inlet manifold which comprises a high frequency (HF) electrode, an impedance monitor electrically coupled to the HF electrode and the LF electrode, a variable capacitor electrically coupled to the chamber and controllably coupled to a processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor, and a matching network electrically coupled to a high frequency RF generator and the gas manifold, wherein the matching network has capacitors that are different from the variable capacitor;

Group 10: Claim 24, which is directed generally to the same subject matter as claim 16, but which includes the additional limitation that the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode;

Group 11: Claim 30, which is directed generally to the same subject matter as claim 24, but which includes the additional limitation that the processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe;

Group 12: Claim 20, which relates generally to a substrate processing system including a substrate holder which comprises a low frequency (LF) electrode, a gas inlet manifold which comprises a high frequency (HF) electrode, an impedance monitor electrically coupled to the HF electrode and the LF electrode, a variable capacitor electrically coupled to the LF electrode and controllably coupled to a processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor, and a matching network coupled between a low frequency RF generator and the variable capacitor, wherein the matching network includes capacitors that are different from the variable capacitor; and

Group 13: Claim 26, which is directed generally to the same subject matter as claim 20, but which includes the additional limitation that the impedance monitor

comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode.

VIII. DISCUSSION OF THE REFERENCES RELIED UPON BY THE EXAMINER:

In rejecting the claims under 35 U.S.C. § 103(a), the Examiner relied upon the following references:

1. Arami (United States Patent No. 6,014,943)

Arami discloses a plasma process device including a process vessel having a plasma generating area therein. A susceptor is provided in the process vessel for supporting a substrate having a process surface. "[A] high frequency power of 2 kW having a frequency of 27.12 MHz is supplied to an upper electrode 22 from the second high frequency power source 34, molecules of the etching gas (e.g., CF_4 gas) present in the process chamber 2 are dissociated to generate a plasma. At the same time, high frequency power (frequency: 800 kHz, power: 1 kW) is supplied to the susceptor 6 from the first frequency power source 31." Column 8, lines 22-29.

2. Patrick et al. (United States Patent No. 5,474,648)

Patrick et al. discloses a plasma processing system, in which an RF generator 102 is coupled to a plasma chamber 104 through a matching network 120 consisting of variable capacitors 106 and 108, and coil 110. The plasma chamber 104 includes electrodes 112 and 114. Column 6, lines 60-64. Maximum transfer of RF power from the RF generator 102 to the electrodes 112 and 114 results when the plasma power load impedance is matched to the impedance of the RF generator 102. Column 7, lines 4-7. "Power sensor 202 measures the radio frequency power being delivered to the plasma chamber 104. A power controller 204 utilizes a signal representative of the measured power from the power sensor 202 to control the amount of power from the RF generator 102. Matching network 120 automatically adjusts to produce a match condition between the RF generator 102 and the plasma chamber 104." Column 7, lines 14-20. Patrick et al. does not disclose the use of both high frequency RF and low frequency RF.

3. Boys et al. (United States Patent No. 4,500,408)

Boys et al. discloses a magnetron sputter coating apparatus having a magnetic field which is controlled in response to measurements of plasma parameters to control deposition parameters, such as sputter deposition rate and material deposition thickness profile. The apparatus 11 includes a vacuum chamber 12 having a metallic, electrically grounded, exterior housing 16 and a target cathode 15 disposed therein (col. 6, lines 15-32). Various parameters are monitored to assist in controlling the opening of a gas valve 32, the current supplied by a DC power source 25 to vary the applied magnetic field, and the current supplied to the target cathode 15 and anode 16 (col. 8, lines 14-18). A DC plasma power source 37 includes a current transformer for supplying to lead 46 a DC signal proportional to the current supplied by the source 37 between electrodes 15 and 16. The source 37 also includes voltage measuring circuitry for supplying lead 45 with a signal indicative of the magnitude of the voltage applied by the source between electrodes 15 and 16. Column 8, lines 18-28.

4. <u>Yamagata et al. (United States Patent No. 5,362,358)</u>

Yamagata et al. discloses a dry etching apparatus and method of forming a via hole in an interlayer insulator. Yamagata et al. discloses variable capacitor 24, 26 which "are controlled such as to apply RF power only to the anode 12" or "solely to the cathode 14" (col. 1, lines 49-59). Yamagata et al. does not disclose a variable capacitor electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor.

IX. ARGUMENTS:

Applicants filed the first appeal brief on July 15, 2002, in response to which the Examiner reopened prosecution by issuing an office action on October 29, 2003. Despite having issued seven office actions in the present application, the Examiner still has not provided clear rejections of each claim on an element-by-element basis, as seen in the arguments below.

Significantly, the rejection of the claims all rely on Patrick et al. Patrick et al. merely discloses an RF parameter sensor 202, and does not show two impedance probes. The Examiner concedes that Patrick et al. does not teach the first and second impedance probes, but

alleges that the duplication of parts is obvious in view of *In re Harza*, 124 U.S.P.Q. 378 (C.C.P.A. 1960).

The Examiner first raised this argument **three years ago** in the Interview Summary mailed August 9, 2000, but did not mention it again after Applicants filed a response on September 22, 2000. After trying different combinations of references over the course of more than three years, the Examiner now returns to the same inapposite argument. This came after the Examiner reopened prosecution pursuant to the first Appeal Brief filed on July 15, 2002, resulting in protracted prosecution of the present application.

Harza does not support the Examiner's conclusion. First, Patrick et al. fails to disclose even one, much less two, impedance probes for measuring the impedance at an electrode as claimed. *Harza* stands for the proposition that mere duplication of parts has no patentable significance, provided that the prior art discloses the part. In *Harza* the part is a rib on a web of a water stop. In the present case, the part is an impedance probe that measures the impedance at an electrode. For instance, claim 11 recites a first impedance probe to measure the impedance at the HF electrode and a second impedance probe to measure the impedance at the LF electrode. Patrick et al. discloses a power sensor (202) for measuring the RF power delivered to the plasma chamber (104) (col. 7, lines 14-15). Patrick et al. states that the "sensor may also measure the voltage, current and phase angle at the chamber electrode, and measure the chamber impedance as desired" (col. 4, lines 26-28). The power sensor in Patrick et al., however, does not measure the impedance at the LF electrode or at the HF electrode. Patrick et al. does not disclose the impedance probe as recited in claim 11. Therefore, the recitation of first and second impedance probes in claim 11 does not constitute mere duplication of a part disclosed in the prior art.

Furthermore, the two impedance probes as recited in claim 11 are novel and produce new and unobvious results. *Harza* states that "mere duplication of parts has no patentable significance unless a new and unexpected result is produced." *Id.* at 380. The court in *Harza* found claims 7 and 10 patentable for reciting "the combination of a plurality of ribs in the offset position." *Id.* at 381. The court reasoned that "the offsetting in combination with the claimed dimensional relationship of the ribs produces new and unobvious results which are not suggested by any combination of the references." *Id.* Similarly, nothing in Patrick et al. or the

other cited references suggests measuring the impedance at the HF electrode with one impedance probe and measuring the impedance at the LF electrode with another impedance probe.

Measuring the impedance separately at the HF electrode and at the LF electrode can provide important information regarding the system and the process. For instance, the specification at page 25, line 25 to page 27, line 14 (Figs. 8-10) describes the use of independent impedance measurements at the HF and LF electrodes in conjunction with other measurements such as phase angle and current intensities to analyze the effects on ion bombardment, wet etch rate, and other film properties. Thus, the claimed system produces new and unobvious results.

The Examiner further alleges that it is well demonstrated by Patrick et al. with the impedance measurement of one electrode using one impedance probe at column 7, line 61 to column 8, line 4, that measuring the impedance separately at the HF electrode and at the LF electrode can provide important information regarding the system and the process. The Examiner, however, fails to recognize that Patrick et al. does not disclose even one impedance probes for measuring the impedance at an electrode. The Examiner has **not** identified any impedance probe in Patrick et al.

The Examiner's response to the argument for patentability of claim 16 is equally baffling. Claim 16 stands rejected as being unpatentable over Arami et al. in view of Patrick et al. The Examiner admits that neither Arami nor Patrick teach a variable capacitor separate from the matching network, but states that the limitation is met by Yamagata et al. (Final Office Action, at page 2, lines 12-15). However, the rejection of claim 16 does **not** include Yamagata et al. In any event, Yamagata et al. does not supply the missing teaching.

The Examiner further alleges that the motivation to add a variable capacitor in Patrick et al. separate from the matching network of a plasma processing chamber is provided in Yamagata et al. at column 1, lines 45-47, which is drawn to controlling the amount of power applied to each of the electrodes in the plasma reactor. The fact remains that nothing in Yamagata et al. discloses or suggests a variable capacitor electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the

impedance monitor. Thus, there is no motivation to combine the references in the manner suggested by the Examiner.

Because all the claims do not stand or fall together, Applicants will present arguments for each claim group.

Claim Group 1

Independent claim 11 and claims 3 and 6 depending therefrom stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al.

Claim 11 recites that the impedance monitor comprises a first impedance probe electrically coupled to the HF electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to the LF electrode to measure the impedance at the LF electrode. A processor is coupled with the impedance monitor for adjusting processing conditions of the deposition chamber based on measurements by the first impedance probe and the second impedance probe. Applicants respectfully assert that claim 11 is patentable over the references because, for instance, they do not teach or suggest the recited impedance monitor and processor.

The Examiner recognizes that Arami et al. does not teach the impedance monitor as recited in claim 11. The Examiner alleges that Patrick et al. discloses an impedance monitor 202 having a first impedance probe electrically coupled to an electrode to measure the impedance at the electrode, and that it would have been obvious to use the Patrick impedance monitor coupled to each of the low and high frequency electrodes of Arami et al. The Examiner alleges that the motivation for using the Patrick impedance monitor electrically coupled to each of Arami's low and high frequency electrodes is directed to providing a chamber impedance measurement and control for uniform processing as taught by Patrick at column 5, line 57, to column 6, line 33.

Applicants note, however, that Patrick et al. is completely devoid of any suggestion for providing two impedance probes electrically coupled to two separate electrodes. Significantly, the plasma chamber 104 in Patrick et al. includes two electrodes 112 and 114. Column 6, lines 60-64. However, Patrick et al. does not disclose two impedance probes electrically coupled to the two electrodes 112 and 114. Given that Patrick et al. does not teach or suggest using two impedance probes electrically coupled to the two electrodes 112 and 114

in its plasma chamber 104, there is no basis for asserting that combining Patrick et al. with Arami et al. would somehow motivate one of ordinary skill in the art to use two impedance probes.

Furthermore, the two impedance probes as recited in claim 11 are novel and produce new and unobvious results. Measuring the impedance separately at the HF electrode and at the LF electrode can provide important information regarding the system and the process. For instance, the specification at page 25, line 25 to page 27, line 14 (Figs. 8-10) describes the use of independent impedance measurements at the HF and LF electrodes in conjunction with other measurements such as phase angle and current intensities to analyze the effects on ion bombardment, wet etch rate, and other film properties. Thus, the claimed system produces new and unobvious results.

The presence of new and unobvious results provides an additional and independent ground for distinguishing over the cited art. The use of two impedance probes is neither taught nor suggested in the cited references. This claimed feature clearly distinguishes over the cited art.

For at least the above reasons, Applicants respectfully submit that independent claim 11, and claims 3 and 6 depending therefrom, are patentable.

Claim Group 2

Claims 4 and 12 stand rejected on the same grounds as claim 11 from which claims 4 and 12 depend. Applicants believe claims 4 and 12 are allowable for the same reasons that claim 11 is allowable. Claims 4 and 12 further recite a variable capacitor electrically coupled to the LF electrode and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. Arami et al. does not disclose a variable capacitor. Patrick et al. discloses variable capacitors 106, 108, but they are not coupled to an LF electrode. Moreover, there is no suggestion in the references to use the variable capacitor of Patrick et al. in the apparatus of Arami et al. The Examiner has engaged in the impermissible exercise of hindsight in the rejection. For at least the foregoing reasons, claims 4 and 12 are patentable.

Claim Group 3

Claim 23 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. and Patrick et al., and further in view of Yamagata et al. Applicants believe claim 23 is allowable for the same reasons that claim 4 is allowable. Claim 23 further recites that the variable capacitor is separate from an RF matching network electrically coupled to the chamber. Arami et al. does not disclose variable capacitors. In Patrick et al., the variable capacitors 106, 108 are part of the matching network 120, as clearly shown in Fig. 2A and stated at column 6, lines 60-63. Nothing in Arami et al. and Patrick et al. teaches or suggests a variable capacitor that is separate from the RF matching network and electrically coupled to the chamber, wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor.

The Examiner cites Yamagata et al. for allegedly disclosing variable capacitors 24, 26 separate from the matching network 22 of a plasma processing chamber. Yamagata et al. discloses variable capacitor 24, 26 which "are controlled such as to apply RF power only to the anode 12" or "solely to the cathode 14" (col. 1, lines 49-59). Nothing in Yamagata et al. discloses or suggests a variable capacitor electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. Furthermore, the Examiner has not pointed to any motivation to combine Yamagata et al. with Arami et al. and Patrick et al. Thus, claim 23 is patentable.

Claim Group 4

Claim 5 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al. The Examiner asserts that it would have been obvious to consider the pressure control system as allegedly described in Boys et al. to be an obvious extension to the Patrick et al. control system and impedance data collection and processing.

Applicants note that Boys et al. does not cure the deficiencies of the other references since Boys et al. also fails to disclose or suggest the impedance monitor and processor as recited in claim 11 from which claim 5 depends. For example, Boys et al. clearly does not teach or suggest the use of two impedance probes. Therefore, claim 5 is patentable.

Claim Group 5

Claims 13, 14, and 19 stand rejected on the same grounds as claim 11 from which claims 13, 14, and 19 depend. Applicants believe claims 13, 14, and 19 are allowable for the same reasons that claim 11 is allowable. Claims 13, 14, and 19 further recite that an impedance tuner is coupled in series to the substrate holder. Arami et al. and Patrick et al. do not teach or suggest coupling an impedance in series to the substrate holder, which comprises the LF electrode as recited in claim 11. Thus, claims 13, 14, and 19 are patentable.

Claim Group 6

Claim 29 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al.

Applicants believe claim 29 is allowable for the same reasons that claim 13 is allowable, since Boys et al. does not cure the deficiencies of Arami et al. and Patrick et al. Claim 29 further recites that the processor is configured to adjust a setting of the impedance tuner based on measurements by the first impedance probe and the second impedance probe. None of the references disclose or suggest the use of two impedance probes to provide measurements which can be used to adjust the setting of an impedance tuner. Therefore, claim 29 is patentable.

Claim Group 7

Claim 27 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al. The Examiner asserts that it would have been obvious to consider the pressure control system as allegedly described in Boys et al. to be an obvious extension to the Patrick et al. control system and impedance data collection and processing.

Applicants believe claim 27 is allowable for the same reasons that claim 11 is allowable, since Boys et al. does not cure the deficiencies of Arami et al. and Patrick et al. Claim 27 further recites that the processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe. None of the references teach or suggest the use of two impedance probes to provide measurements which can be used to adjust the pressure in the deposition chamber. Thus, claim 27 is patentable.

Claim Group 8

Claim 28 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al.

Applicants believe claim 28 is allowable for the same reasons that claim 11 is allowable, since Boys et al. does not cure the deficiencies of Arami et al. and Patrick et al. Claim 28 further recites that the processor is configured to adjust at least one of a high frequency RF power level of the power source and a low frequency RF power level of the power source, based on measurements by the first impedance probe and the second impedance probe. None of the references disclose or suggest the use of two impedance probes to provide measurements which can be used to adjust at least one of the high frequency RF power level of the power source and a low frequency RF power level of the power source. Thus, claim 28 is patentable.

Claim Group 9

Claim 16 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al.

Applicants respectfully submit that independent claim 16 is patentable over Arami et al. and Patrick et al. because, for instance, they do not teach or suggest a matching network electrically coupled to a high frequency RF generator and the gas manifold, wherein the matching network has capacitors that are different than the variable capacitor which is electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor.

The Examiner recognizes that Arami does not teach capacitors in the matching networks, but alleges that Patrick et al. discloses such capacitors. The Examiner does **not** allege that the capacitors in Patrick et al. are different from a variable capacitor which is electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. In fact, the Examiner states at page 2, lines 12-13 of the Final Office Action: "Neither Arami nor Patrick teach a variable capacitor separate from the matching network."

For at least the foregoing reasons, claim 16 is patentable.

Claim Group 10

Claim 24 stands rejected on the same grounds as claim 16 from which claim 24 depends. Applicants believe claim 24 is allowable for the same reasons that claim 16 is allowable. Claim 24 further recites that the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode. Arami et al. and Patrick et al. both fail to teach or suggest the use of two impedance probes. Thus, claim 24 is patentable.

Claim Group 11

Claim 30 depends from claim 24, and stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al. The Examiner asserts that it would have been obvious to consider the pressure control system as allegedly described in Boys et al. to be an obvious extension to the Patrick et al. control system and impedance data collection and processing.

Applicants believe claim 30 is allowable for the same reasons that claim 24 is allowable, since Boys et al. does not cure the deficiencies of Arami et al. and Patrick et al. Claim 30 further recites that the computer processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe. None of the references teach or suggest the use of two impedance probes to provide measurements which can be used to adjust the pressure in the deposition chamber. Thus, claim 30 is patentable.

Claim Group 12

Claim 20 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al.

Applicants respectfully contend that independent claim 20 is patentable over Arami et al. and Patrick et al. because, for instance, they do not teach or suggest a matching network coupled between a low frequency RF generator and the variable capacitor, wherein the matching network includes capacitors that are different than the variable capacitor which is electrically coupled to the LF electrode and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. As discussed above, the Examiner

<u>states at page 2, lines 12-13 of the Final Office Action: "Neither Arami nor Patrick teach a variable capacitor separate from the matching network."</u>

For at least the foregoing reasons, claim 20 is patentable.

<u>Claim Group 13</u>

Claim 26 stands rejected on the same grounds as claim 20 from which claim 26 depends. Applicants believe claim 26 is allowable for the same reasons that claim 20 is allowable. Claim 26 further recites that the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode. Arami et al. and Patrick et al. both fail to teach or suggest the use of two impedance probes. Thus, claim 26 is patentable.

X. <u>CONCLUSION:</u>

In view of the foregoing arguments distinguishing claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 over the art of record, Applicants respectfully submit that the claims are in condition for allowance, and respectfully request that the rejection of these claims be reversed.

Respectfully submitted,

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Encl.: Appendix of claims involved in appeal

APPENDIX

3. The substrate processing system of claim 11 wherein said processor receives as an input the measured impedance level of said plasma.

4. The substrate processing system of claim 3 further comprising a variable capacitor electrically coupled to said chamber and controllably coupled to said processor wherein said processor adjusts a capacitance level of said variable capacitor to vary the impedance of said plasma in response to an output of said impedance monitor.

5. The substrate processing system of claim 3 further comprising a pressure control system configured to control a pressure level within said chamber and controllably coupled to said processor wherein said processor controls said pressure control system to vary the pressure within the chamber in response to the measured impedance level of said plasma.

6. The substrate processing system of claim 3 wherein said processor controls said plasma power source to vary the power applied to the plasma in response to the measured impedance level of said plasma.

11. A substrate processing system comprising:

a deposition chamber comprising a reaction zone;

a substrate holder that positions a substrate in the reaction zone;

said substrate holder comprising a low frequency (LF) electrode;

a gas distribution system that includes a gas inlet manifold for supplying one or more process gases to said reaction zone;

said gas inlet manifold comprising a high frequency (HF) electrode;

a plasma power source for forming a plasma within the reaction zone of said deposition chamber, the plasma power source comprising a high frequency power supply coupled with the HF electrode and a low frequency power supply coupled with the LF electrode;

an impedance monitor comprising a first impedance probe electrically coupled to said high frequency electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to said low frequency electrode to measure the impedance at the LF electrode; and

a processor coupled with the impedance monitor for adjusting processing conditions of the deposition chamber based on measurements by the first impedance probe and the second impedance probe.

12. The substrate processing system of claim 11 further comprising a variable capacitor electrically coupled to said LF electrode and controllably coupled to said processor wherein said processor adjusts a capacitance level of said variable capacitor to vary the impedance of said plasma in response to an output of said impedance monitor.

13. The substrate processing system of claim 11 further comprising an impedance tuner coupled in series to said substrate holder.

14. The substrate processing system of claim 13 wherein said impedance tuner is coupled between said substrate holder and a low frequency RF generator.

16. A substrate processing system comprising:

a deposition chamber comprising a reaction zone;

a substrate holder that positions a substrate in the reaction zone;

said substrate holder comprising a low frequency (LF) electrode;

a gas distribution system that includes a gas inlet manifold for supplying one or more process gases to said reaction zone;

said gas inlet manifold comprising a high frequency (HF) electrode;

a plasma power source for forming a plasma within the reaction zone of said deposition chamber, the plasma power source comprising a high frequency power supply coupled with the HF electrode and a low frequency power supply coupled with the LF electrode;

an impedance monitor electrically coupled to said high frequency electrode and said low frequency electrode;

a computer processor communicatively coupled to said impedance monitor so that said computer processor receives as an input the measured impedance level of said plasma;

a variable capacitor electrically coupled to said chamber and controllably coupled to said processor wherein said processor adjusts a capacitance level of said variable capacitor to vary the impedance of said plasma in response to an output of said impedance monitor; and

a matching network electrically coupled to a high frequency RF generator and said gas manifold, wherein said matching network has capacitors that are different than said variable capacitor.

19. The substrate processing system of claim 14, wherein said impedance tuner includes a variable capacitor.

20. A substrate processing system comprising:

a deposition chamber comprising a reaction zone;

a substrate holder that positions a substrate in the reaction zone;

said substrate holder comprising a low frequency (LF) electrode;

a gas distribution system that includes a gas inlet manifold for supplying one or more process gases to said reaction zone;

said gas inlet manifold comprising a high frequency (HF) electrode;

a plasma power source for forming a plasma within the reaction zone of said deposition chamber, the plasma power source comprising a high frequency power supply coupled with the HF electrode and a low frequency power supply coupled with the LF electrode;

an impedance monitor electrically coupled to said high frequency electrode and said low frequency electrode, said impedance monitor including an impedance monitor variable capacitor;

a processor communicatively coupled to said impedance monitor for receiving as an input a measured impedance level of said plasma;

a variable capacitor electrically coupled to said LF electrode and controllably coupled to said processor wherein said processor adjusts a capacitance level of said variable capacitor to vary the impedance of said plasma in response to an output of said impedance monitor; and

a matching network coupled between a low frequency RF generator and said variable capacitor, wherein said matching network includes capacitors that are different than said variable capacitor.

23. The substrate processing system of claim 4 further comprising an RF matching network electrically coupled to the chamber, and wherein the variable capacitor is separate from the matching network.

24. The substrate processing system of claim 16 wherein the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode.

26. The substrate processing system of claim 20 wherein the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode.

27. The substrate processing system of claim 11 wherein the processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe.

28. The substrate processing system of claim 11 wherein the processor is configured to adjust at least one of a high frequency RF power level of the power source and a low frequency RF power level of the power source, based on measurements by the first impedance probe and the second impedance probe.

29. The substrate processing system of claim 13 wherein the processor is configured to adjust a setting of the impedance tuner based on measurements by the first impedance probe and the second impedance probe.

30. The substrate processing system of claim 24 wherein the computer processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe.

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PATENT & TRADEMARK OFFICE

PATENT
Attorney Docket No.: 1771X2T19930
TTC No.: 16301-019930

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES**

In re application of:	Examiner: Rudy Zervigon
SEBASTIEN RAOUX et al.	Art Unit: 1763
Application No.: 08/988,246	APPELLANT'S BRIEF UNDER 37 CFR § 1.192
Filed: December 1, 1997	
For: METHOD AND APPARATUS FOR MONITORING AND ADJUSTING CHAMBER IMPEDANCE	

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Applicants, in the above-captioned patent application, appeal the final rejection of claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30. The claims on appeal have been finally rejected pursuant to MPEP § 706.07(b). Accordingly, this appeal is believed to be proper. This appeal brief is filed in triplicate.

I. REAL PARTY IN INTEREST:

The real party in interest for the above-identified application is APPLIED MATERIALS, INC., a Delaware corporation having its principal place of business at P.O. Box 450A, Santa Clara, California 95052. The assignment is recorded in the U.S. Patent and Trademark Office on December 1, 1997 at Reel 8897/Frame 0170.

II. RELATED APPEALS AND INTERFERENCES:

There are no appeals or interferences related to the present appeal.

III. STATUS OF CLAIMS:

Claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 are pending.

Claims 3, 4, 6, 11-14, 16, 19, 20, 24, 26, 28, and 29 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al. Claims 5, 27, and 30 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al.

Claim 23 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. and Patrick et al., and further in view of Yamagata et al.

Claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-5 of U.S. Patent No. 6,098,568 in view of Patrick et al.

Claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-6 of U.S. Patent No. 6,041,734 in view of Patrick et al.

IV. STATUS OF AMENDMENTS:

Claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 were rejected under 35 U.S.C. § 103(a) upon the grounds set forth in the Final Office Action mailed on July 24, 2003.

Applicants filed a Response under 37 C.F.R. § 1.116 on September 24, 2003. No amendments were made. An Advisory Action mailed November 3, 2003 indicated that the Response would not be entered. A terminal disclaimer was filed on January 9, 2004 to overcome the rejections under the judicially created doctrine of obviousness-type double patenting.

In accordance with 37 C.F.R. § 1.192(c)(9), a copy of the claims involved in the appeal are contained in the Appendix attached hereto.

V. SUMMARY OF THE INVENTION:

Embodiments of the present invention provide an apparatus for depositing CVD films on a substrate. The apparatus employs mixed frequency RF power and provides a gas distribution manifold for directing process gases into the chamber. The potential for arcing is greatly reduced by connecting the low frequency RF power source to a low frequency (LF) electrode embedded in the substrate holder and connecting the high frequency RF power source to the gas distribution manifold, which also functions as a high frequency (HF)

electrode. An impedance monitor comprises a first impedance probe electrically coupled to the high frequency electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to the low frequency electrode to measure the impedance at the LF electrode. An independent matching network decouples the low frequency waveform from the high frequency waveform to minimize phase interferences between the waveforms. These features combine to allow deposition processes to proceed at conditions that were unattainable in prior substrate processing chambers and also enable the substrate processing apparatus of the present invention to be usable in sub-0.35 μm deposition processes including 0.25 and 0.18 μm processes.

According to an embodiment of the present invention, a substrate processing system comprises a deposition chamber comprising a reaction zone and a substrate holder that positions a substrate in the reaction zone. The substrate holder comprises a low frequency (LF) electrode. A gas distribution system includes a gas inlet manifold for supplying one or more process gases to the reaction zone. The gas inlet manifold comprises a high frequency (HF) electrode. A plasma power source is provided for forming a plasma within the reaction zone of the deposition chamber, and comprises a high frequency power supply coupled with the HF electrode and a low frequency power supply coupled with the LF electrode. An impedance monitor comprises a first impedance probe electrically coupled to the high frequency electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to the low frequency electrode to measure the impedance at the LF electrode. A processor is coupled with the impedance monitor for adjusting processing conditions of the deposition chamber based on measurements by the first impedance probe and the second impedance probe.

In another embodiment of the invention, a variable capacitor is electrically coupled to the chamber and controllably coupled to the processor, wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. A matching network is electrically coupled to a high frequency RF generator and the gas manifold, wherein the matching network has capacitors that are different from the variable capacitor.

In another embodiment, a processor is communicatively coupled to the impedance monitor for receiving as an input a measured impedance level of the plasma. A variable capacitor is electrically coupled to the LF electrode and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. A matching network is coupled between a low frequency RF generator and the variable capacitor, wherein the matching network includes capacitors that are different from the variable capacitor.

VI. ISSUES:

The following issues are presented:

Whether claims 3, 4, 6, 11-14, 16, 19, 20, 24, 26, 28, and 29 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al.

Whether claims 5, 27, and 30 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al.

Whether claim 23 is properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. and Patrick et al., and further in view of Yamagata et al.

VII. GROUPING OF THE CLAIMS:

In the present case, the rejected claims do not all stand or fall together. Applicants submit that each claim presents distinct issues concerning patentability. In the interest of administrative economy and efficiency, however, Applicants agree to narrow the issues for the purposes of this appeal only by grouping the claims as follows:

Group 1: Claims 11, 3, and 6, which relate generally to a substrate processing system including a substrate holder which comprises a low frequency (LF) electrode, a gas inlet manifold which comprises a high frequency (HF) electrode, an impedance monitor comprising a first impedance probe electrically coupled to the HF electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to the LF electrode to measure the impedance at the LF electrode, and a processor coupled with the impedance

monitor for adjusting processing conditions of the deposition chamber based on measurements by the first impedance probe and the second impedance probe;

Group 2: Claims 4 and 12, which are directed generally to the same subject matter as claim 11, but which include the additional limitation that the processor adjusts a capacitance level of a variable capacitor electrically coupled to the chamber to vary the impedance of the plasma in response to an output of the impedance monitor;

Group 3: Claim 23, which is directed generally to the same subject matter as claim 4, but which includes the additional limitation that the variable capacitor is separate from an RF matching network electrically coupled to the chamber;

Group 4: Claim 5, which is directed generally to the same subject matter as claim 3, but which includes the additional limitation that the processor controls a pressure control system to vary the pressure within the chamber in response to the measured impedance level of the plasma;

Group 5: Claims 13, 14, and 19, which are directed generally to the same subject matter as claim 11, but which include the additional limitation that an impedance tuner is coupled in series to the substrate holder.

Group 6: Claim 29, which is directed generally to the same subject matter as claim 13, but which includes the additional limitation that the processor is configured to adjust a setting of the impedance tuner based on measurements by the first impedance probe and the second impedance probe;

Group 7: Claim 27, which is directed generally to the same subject matter as claim 11, but which includes the additional limitation that the processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe;

Group 8: Claim 28, which is directed generally to the same subject matter as claim 11, but which includes the additional limitation that the processor is configured to adjust at least one of a high frequency RF power level of the power source and a low frequency RF power level of the power source, based on measurements by the first impedance probe and the second impedance probe;

Group 9: Claim 16, which relates generally to a substrate processing system including a substrate holder which comprises a low frequency (LF) electrode, a gas inlet manifold which comprises a high frequency (HF) electrode, an impedance monitor electrically coupled to the HF electrode and the LF electrode, a variable capacitor electrically coupled to the chamber and controllably coupled to a processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor, and a matching network electrically coupled to a high frequency RF generator and the gas manifold, wherein the matching network has capacitors that are different from the variable capacitor;

Group 10: Claim 24, which is directed generally to the same subject matter as claim 16, but which includes the additional limitation that the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode;

Group 11: Claim 30, which is directed generally to the same subject matter as claim 24, but which includes the additional limitation that the processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe;

Group 12: Claim 20, which relates generally to a substrate processing system including a substrate holder which comprises a low frequency (LF) electrode, a gas inlet manifold which comprises a high frequency (HF) electrode, an impedance monitor electrically coupled to the HF electrode and the LF electrode, a variable capacitor electrically coupled to the LF electrode and controllably coupled to a processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor, and a matching network coupled between a low frequency RF generator and the variable capacitor, wherein the matching network includes capacitors that are different from the variable capacitor; and

Group 13: Claim 26, which is directed generally to the same subject matter as claim 20, but which includes the additional limitation that the impedance monitor

comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode.

VIII. DISCUSSION OF THE REFERENCES RELIED UPON BY THE EXAMINER:

In rejecting the claims under 35 U.S.C. § 103(a), the Examiner relied upon the following references:

1. Arami (United States Patent No. 6,014,943)

Arami discloses a plasma process device including a process vessel having a plasma generating area therein. A susceptor is provided in the process vessel for supporting a substrate having a process surface. "[A] high frequency power of 2 kW having a frequency of 27.12 MHz is supplied to an upper electrode 22 from the second high frequency power source 34, molecules of the etching gas (e.g., CF_4 gas) present in the process chamber 2 are dissociated to generate a plasma. At the same time, high frequency power (frequency: 800 kHz, power: 1 kW) is supplied to the susceptor 6 from the first frequency power source 31." Column 8, lines 22-29.

2. Patrick et al. (United States Patent No. 5,474,648)

Patrick et al. discloses a plasma processing system, in which an RF generator 102 is coupled to a plasma chamber 104 through a matching network 120 consisting of variable capacitors 106 and 108, and coil 110. The plasma chamber 104 includes electrodes 112 and 114. Column 6, lines 60-64. Maximum transfer of RF power from the RF generator 102 to the electrodes 112 and 114 results when the plasma power load impedance is matched to the impedance of the RF generator 102. Column 7, lines 4-7. "Power sensor 202 measures the radio frequency power being delivered to the plasma chamber 104. A power controller 204 utilizes a signal representative of the measured power from the power sensor 202 to control the amount of power from the RF generator 102. Matching network 120 automatically adjusts to produce a match condition between the RF generator 102 and the plasma chamber 104." Column 7, lines 14-20. Patrick et al. does not disclose the use of both high frequency RF and low frequency RF.

3. Boys et al. (United States Patent No. 4,500,408)

Boys et al. discloses a magnetron sputter coating apparatus having a magnetic field which is controlled in response to measurements of plasma parameters to control deposition parameters, such as sputter deposition rate and material deposition thickness profile. The apparatus 11 includes a vacuum chamber 12 having a metallic, electrically grounded, exterior housing 16 and a target cathode 15 disposed therein (col. 6, lines 15-32). Various parameters are monitored to assist in controlling the opening of a gas valve 32, the current supplied by a DC power source 25 to vary the applied magnetic field, and the current supplied to the target cathode 15 and anode 16 (col. 8, lines 14-18). A DC plasma power source 37 includes a current transformer for supplying to lead 46 a DC signal proportional to the current supplied by the source 37 between electrodes 15 and 16. The source 37 also includes voltage measuring circuitry for supplying lead 45 with a signal indicative of the magnitude of the voltage applied by the source between electrodes 15 and 16. Column 8, lines 18-28.

4. Yamagata et al. (United States Patent No. 5,362,358)

Yamagata et al. discloses a dry etching apparatus and method of forming a via hole in an interlayer insulator. Yamagata et al. discloses variable capacitor 24, 26 which "are controlled such as to apply RF power only to the anode 12" or "solely to the cathode 14" (col. 1, lines 49-59). Yamagata et al. does not disclose a variable capacitor electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor.

IX. ARGUMENTS:

Applicants filed the first appeal brief on July 15, 2002, in response to which the Examiner reopened prosecution by issuing an office action on October 29, 2003. Despite having issued seven office actions in the present application, the Examiner still has not provided clear rejections of each claim on an element-by-element basis, as seen in the arguments below.

Significantly, the rejection of the claims all rely on Patrick et al. Patrick et al. merely discloses an RF parameter sensor 202, and does not show two impedance probes. The Examiner concedes that Patrick et al. does not teach the first and second impedance probes, but

alleges that the duplication of parts is obvious in view of *In re Harza*, 124 U.S.P.Q. 378 (C.C.P.A. 1960).

The Examiner first raised this argument **three years ago** in the Interview Summary mailed August 9, 2000, but did not mention it again after Applicants filed a response on September 22, 2000. After trying different combinations of references over the course of more than three years, the Examiner now returns to the same inapposite argument. This came after the Examiner reopened prosecution pursuant to the first Appeal Brief filed on July 15, 2002, resulting in protracted prosecution of the present application.

Harza does not support the Examiner's conclusion. First, Patrick et al. fails to disclose even one, much less two, impedance probes for measuring the impedance at an electrode as claimed. *Harza* stands for the proposition that mere duplication of parts has no patentable significance, provided that the prior art discloses the part. In *Harza* the part is a rib on a web of a water stop. In the present case, the part is an impedance probe that measures the impedance at an electrode. For instance, claim 11 recites a first impedance probe to measure the impedance at the HF electrode and a second impedance probe to measure the impedance at the LF electrode. Patrick et al. discloses a power sensor (202) for measuring the RF power delivered to the plasma chamber (104) (col. 7, lines 14-15). Patrick et al. states that the "sensor may also measure the voltage, current and phase angle at the chamber electrode, and measure the chamber impedance as desired" (col. 4, lines 26-28). The power sensor in Patrick et al., however, does not measure the impedance at the LF electrode or at the HF electrode. Patrick et al. does not disclose the impedance probe as recited in claim 11. Therefore, the recitation of first and second impedance probes in claim 11 does not constitute mere duplication of a part disclosed in the prior art.

Furthermore, the two impedance probes as recited in claim 11 are novel and produce new and unobvious results. *Harza* states that "mere duplication of parts has no patentable significance unless a new and unexpected result is produced." *Id.* at 380. The court in *Harza* found claims 7 and 10 patentable for reciting "the combination of a plurality of ribs in the offset position." *Id.* at 381. The court reasoned that "the offsetting in combination with the claimed dimensional relationship of the ribs produces new and unobvious results which are not suggested by any combination of the references." *Id.* Similarly, nothing in Patrick et al. or the

other cited references suggests measuring the impedance at the HF electrode with one impedance probe and measuring the impedance at the LF electrode with another impedance probe.

Measuring the impedance separately at the HF electrode and at the LF electrode can provide important information regarding the system and the process. For instance, the specification at page 25, line 25 to page 27, line 14 (Figs. 8-10) describes the use of independent impedance measurements at the HF and LF electrodes in conjunction with other measurements such as phase angle and current intensities to analyze the effects on ion bombardment, wet etch rate, and other film properties. Thus, the claimed system produces new and unobvious results.

The Examiner further alleges that it is well demonstrated by Patrick et al. with the impedance measurement of one electrode using one impedance probe at column 7, line 61 to column 8, line 4, that measuring the impedance separately at the HF electrode and at the LF electrode can provide important information regarding the system and the process. The Examiner, however, fails to recognize that Patrick et al. does not disclose even one impedance probes for measuring the impedance at an electrode. The Examiner has **not** identified any impedance probe in Patrick et al.

The Examiner's response to the argument for patentability of claim 16 is equally baffling. Claim 16 stands rejected as being unpatentable over Arami et al. in view of Patrick et al. The Examiner admits that neither Arami nor Patrick teach a variable capacitor separate from the matching network, but states that the limitation is met by Yamagata et al. (Final Office Action, at page 2, lines 12-15). However, the rejection of claim 16 does **not** include Yamagata et al. In any event, Yamagata et al. does not supply the missing teaching.

The Examiner further alleges that the motivation to add a variable capacitor in Patrick et al. separate from the matching network of a plasma processing chamber is provided in Yamagata et al. at column 1, lines 45-47, which is drawn to controlling the amount of power applied to each of the electrodes in the plasma reactor. The fact remains that nothing in Yamagata et al. discloses or suggests a variable capacitor electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the

impedance monitor. Thus, there is no motivation to combine the references in the manner suggested by the Examiner.

Because all the claims do not stand or fall together, Applicants will present arguments for each claim group.

Claim Group 1

Independent claim 11 and claims 3 and 6 depending therefrom stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al.

Claim 11 recites that the impedance monitor comprises a first impedance probe electrically coupled to the HF electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to the LF electrode to measure the impedance at the LF electrode. A processor is coupled with the impedance monitor for adjusting processing conditions of the deposition chamber based on measurements by the first impedance probe and the second impedance probe. Applicants respectfully assert that claim 11 is patentable over the references because, for instance, they do not teach or suggest the recited impedance monitor and processor.

The Examiner recognizes that Arami et al. does not teach the impedance monitor as recited in claim 11. The Examiner alleges that Patrick et al. discloses an impedance monitor 202 having a first impedance probe electrically coupled to an electrode to measure the impedance at the electrode, and that it would have been obvious to use the Patrick impedance monitor coupled to each of the low and high frequency electrodes of Arami et al. The Examiner alleges that the motivation for using the Patrick impedance monitor electrically coupled to each of Arami's low and high frequency electrodes is directed to providing a chamber impedance measurement and control for uniform processing as taught by Patrick at column 5, line 57, to column 6, line 33.

Applicants note, however, that Patrick et al. is completely devoid of any suggestion for providing two impedance probes electrically coupled to two separate electrodes. Significantly, the plasma chamber 104 in Patrick et al. includes two electrodes 112 and 114. Column 6, lines 60-64. However, Patrick et al. does not disclose two impedance probes electrically coupled to the two electrodes 112 and 114. Given that Patrick et al. does not teach or suggest using two impedance probes electrically coupled to the two electrodes 112 and 114

in its plasma chamber 104, there is no basis for asserting that combining Patrick et al. with Arami et al. would somehow motivate one of ordinary skill in the art to use two impedance probes.

Furthermore, the two impedance probes as recited in claim 11 are novel and produce new and unobvious results. Measuring the impedance separately at the HF electrode and at the LF electrode can provide important information regarding the system and the process. For instance, the specification at page 25, line 25 to page 27, line 14 (Figs. 8-10) describes the use of independent impedance measurements at the HF and LF electrodes in conjunction with other measurements such as phase angle and current intensities to analyze the effects on ion bombardment, wet etch rate, and other film properties. Thus, the claimed system produces new and unobvious results.

The presence of new and unobvious results provides an additional and independent ground for distinguishing over the cited art. The use of two impedance probes is neither taught nor suggested in the cited references. This claimed feature clearly distinguishes over the cited art.

For at least the above reasons, Applicants respectfully submit that independent claim 11, and claims 3 and 6 depending therefrom, are patentable.

Claim Group 2

Claims 4 and 12 stand rejected on the same grounds as claim 11 from which claims 4 and 12 depend. Applicants believe claims 4 and 12 are allowable for the same reasons that claim 11 is allowable. Claims 4 and 12 further recite a variable capacitor electrically coupled to the LF electrode and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. Arami et al. does not disclose a variable capacitor. Patrick et al. discloses variable capacitors 106, 108, but they are not coupled to an LF electrode. Moreover, there is no suggestion in the references to use the variable capacitor of Patrick et al. in the apparatus of Arami et al. The Examiner has engaged in the impermissible exercise of hindsight in the rejection. For at least the foregoing reasons, claims 4 and 12 are patentable.

Claim Group 3

Claim 23 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. and Patrick et al., and further in view of Yamagata et al. Applicants believe claim 23 is allowable for the same reasons that claim 4 is allowable. Claim 23 further recites that the variable capacitor is separate from an RF matching network electrically coupled to the chamber. Arami et al. does not disclose variable capacitors. In Patrick et al., the variable capacitors 106, 108 are part of the matching network 120, as clearly shown in Fig. 2A and stated at column 6, lines 60-63. Nothing in Arami et al. and Patrick et al. teaches or suggests a variable capacitor that is separate from the RF matching network and electrically coupled to the chamber, wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor.

The Examiner cites Yamagata et al. for allegedly disclosing variable capacitors 24, 26 separate from the matching network 22 of a plasma processing chamber. Yamagata et al. discloses variable capacitor 24, 26 which "are controlled such as to apply RF power only to the anode 12" or "solely to the cathode 14" (col. 1, lines 49-59). Nothing in Yamagata et al. discloses or suggests a variable capacitor electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. Furthermore, the Examiner has not pointed to any motivation to combine Yamagata et al. with Arami et al. and Patrick et al. Thus, claim 23 is patentable.

<u>Claim Group 4</u>

Claim 5 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al. The Examiner asserts that it would have been obvious to consider the pressure control system as allegedly described in Boys et al. to be an obvious extension to the Patrick et al. control system and impedance data collection and processing.

Applicants note that Boys et al. does not cure the deficiencies of the other references since Boys et al. also fails to disclose or suggest the impedance monitor and processor as recited in claim 11 from which claim 5 depends. For example, Boys et al. clearly does not teach or suggest the use of two impedance probes. Therefore, claim 5 is patentable.

<u>Claim Group 5</u>

Claims 13, 14, and 19 stand rejected on the same grounds as claim 11 from which claims 13, 14, and 19 depend. Applicants believe claims 13, 14, and 19 are allowable for the same reasons that claim 11 is allowable. Claims 13, 14, and 19 further recite that an impedance tuner is coupled in series to the substrate holder. Arami et al. and Patrick et al. do not teach or suggest coupling an impedance in series to the substrate holder, which comprises the LF electrode as recited in claim 11. Thus, claims 13, 14, and 19 are patentable.

Claim Group 6

Claim 29 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al.

Applicants believe claim 29 is allowable for the same reasons that claim 13 is allowable, since Boys et al. does not cure the deficiencies of Arami et al. and Patrick et al. Claim 29 further recites that the processor is configured to adjust a setting of the impedance tuner based on measurements by the first impedance probe and the second impedance probe. None of the references disclose or suggest the use of two impedance probes to provide measurements which can be used to adjust the setting of an impedance tuner. Therefore, claim 29 is patentable.

Claim Group 7

Claim 27 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al. The Examiner asserts that it would have been obvious to consider the pressure control system as allegedly described in Boys et al. to be an obvious extension to the Patrick et al. control system and impedance data collection and processing.

Applicants believe claim 27 is allowable for the same reasons that claim 11 is allowable, since Boys et al. does not cure the deficiencies of Arami et al. and Patrick et al. Claim 27 further recites that the processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe. None of the references teach or suggest the use of two impedance probes to provide measurements which can be used to adjust the pressure in the deposition chamber. Thus, claim 27 is patentable.

Claim Group 8

Claim 28 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al.

Applicants believe claim 28 is allowable for the same reasons that claim 11 is allowable, since Boys et al. does not cure the deficiencies of Arami et al. and Patrick et al. Claim 28 further recites that the processor is configured to adjust at least one of a high frequency RF power level of the power source and a low frequency RF power level of the power source, based on measurements by the first impedance probe and the second impedance probe. None of the references disclose or suggest the use of two impedance probes to provide measurements which can be used to adjust at least one of the high frequency RF power level of the power source and a low frequency RF power level of the power source. Thus, claim 28 is patentable.

Claim Group 9

Claim 16 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al.

Applicants respectfully submit that independent claim 16 is patentable over Arami et al. and Patrick et al. because, for instance, they do not teach or suggest a matching network electrically coupled to a high frequency RF generator and the gas manifold, wherein the matching network has capacitors that are different than the variable capacitor which is electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor.

The Examiner recognizes that Arami does not teach capacitors in the matching networks, but alleges that Patrick et al. discloses such capacitors. The Examiner does **not** allege that the capacitors in Patrick et al. are different from a variable capacitor which is electrically coupled to the chamber and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. In fact, the Examiner states at page 2, lines 12-13 of the Final Office Action: "Neither Arami nor Patrick teach a variable capacitor separate from the matching network."

For at least the foregoing reasons, claim 16 is patentable.

Claim Group 10

Claim 24 stands rejected on the same grounds as claim 16 from which claim 24 depends. Applicants believe claim 24 is allowable for the same reasons that claim 16 is allowable. Claim 24 further recites that the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode. Arami et al. and Patrick et al. both fail to teach or suggest the use of two impedance probes. Thus, claim 24 is patentable.

Claim Group 11

Claim 30 depends from claim 24, and stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al., and further in view of Boys et al. The Examiner asserts that it would have been obvious to consider the pressure control system as allegedly described in Boys et al. to be an obvious extension to the Patrick et al. control system and impedance data collection and processing.

Applicants believe claim 30 is allowable for the same reasons that claim 24 is allowable, since Boys et al. does not cure the deficiencies of Arami et al. and Patrick et al. Claim 30 further recites that the computer processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe. None of the references teach or suggest the use of two impedance probes to provide measurements which can be used to adjust the pressure in the deposition chamber. Thus, claim 30 is patentable.

Claim Group 12

Claim 20 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Arami et al. in view of Patrick et al.

Applicants respectfully contend that independent claim 20 is patentable over Arami et al. and Patrick et al. because, for instance, they do not teach or suggest a matching network coupled between a low frequency RF generator and the variable capacitor, wherein the matching network includes capacitors that are different than the variable capacitor which is electrically coupled to the LF electrode and controllably coupled to the processor wherein the processor adjusts a capacitance level of the variable capacitor to vary the impedance of the plasma in response to an output of the impedance monitor. As discussed above, the Examiner

states at page 2, lines 12-13 of the Final Office Action: "Neither Arami nor Patrick teach a variable capacitor separate from the matching network."

For at least the foregoing reasons, claim 20 is patentable.

Claim Group 13

Claim 26 stands rejected on the same grounds as claim 20 from which claim 26 depends. Applicants believe claim 26 is allowable for the same reasons that claim 20 is allowable. Claim 26 further recites that the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode. Arami et al. and Patrick et al. both fail to teach or suggest the use of two impedance probes. Thus, claim 26 is patentable.

X. CONCLUSION:

In view of the foregoing arguments distinguishing claims 3-6, 11-14, 16, 19, 20, 23, 24, and 26-30 over the art of record, Applicants respectfully submit that the claims are in condition for allowance, and respectfully request that the rejection of these claims be reversed.

Respectfully submitted,

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Encl.: Appendix of claims involved in appeal

APPENDIX

3. The substrate processing system of claim 11 wherein said processor receives as an input the measured impedance level of said plasma.

4. The substrate processing system of claim 3 further comprising a variable capacitor electrically coupled to said chamber and controllably coupled to said processor wherein said processor adjusts a capacitance level of said variable capacitor to vary the impedance of said plasma in response to an output of said impedance monitor.

5. The substrate processing system of claim 3 further comprising a pressure control system configured to control a pressure level within said chamber and controllably coupled to said processor wherein said processor controls said pressure control system to vary the pressure within the chamber in response to the measured impedance level of said plasma.

6. The substrate processing system of claim 3 wherein said processor controls said plasma power source to vary the power applied to the plasma in response to the measured impedance level of said plasma.

11. A substrate processing system comprising:

a deposition chamber comprising a reaction zone;

a substrate holder that positions a substrate in the reaction zone;

said substrate holder comprising a low frequency (LF) electrode;

a gas distribution system that includes a gas inlet manifold for supplying one or more process gases to said reaction zone;

said gas inlet manifold comprising a high frequency (HF) electrode;

a plasma power source for forming a plasma within the reaction zone of said deposition chamber, the plasma power source comprising a high frequency power supply coupled with the HF electrode and a low frequency power supply coupled with the LF electrode;

an impedance monitor comprising a first impedance probe electrically coupled to said high frequency electrode to measure the impedance at the HF electrode and a second impedance probe electrically coupled to said low frequency electrode to measure the impedance at the LF electrode; and

a processor coupled with the impedance monitor for adjusting processing conditions of the deposition chamber based on measurements by the first impedance probe and the second impedance probe.

12. The substrate processing system of claim 11 further comprising a variable capacitor electrically coupled to said LF electrode and controllably coupled to said processor wherein said processor adjusts a capacitance level of said variable capacitor to vary the impedance of said plasma in response to an output of said impedance monitor.

13. The substrate processing system of claim 11 further comprising an impedance tuner coupled in series to said substrate holder.

14. The substrate processing system of claim 13 wherein said impedance tuner is coupled between said substrate holder and a low frequency RF generator.

16. A substrate processing system comprising:

a deposition chamber comprising a reaction zone;

a substrate holder that positions a substrate in the reaction zone;

said substrate holder comprising a low frequency (LF) electrode;

a gas distribution system that includes a gas inlet manifold for supplying one or more process gases to said reaction zone;

said gas inlet manifold comprising a high frequency (HF) electrode;

a plasma power source for forming a plasma within the reaction zone of said deposition chamber, the plasma power source comprising a high frequency power supply coupled with the HF electrode and a low frequency power supply coupled with the LF electrode;

an impedance monitor electrically coupled to said high frequency electrode and said low frequency electrode;

a computer processor communicatively coupled to said impedance monitor so that said computer processor receives as an input the measured impedance level of said plasma;

a variable capacitor electrically coupled to said chamber and controllably coupled to said processor wherein said processor adjusts a capacitance level of said variable capacitor to vary the impedance of said plasma in response to an output of said impedance monitor; and

a matching network electrically coupled to a high frequency RF generator and said gas manifold, wherein said matching network has capacitors that are different than said variable capacitor.

19. The substrate processing system of claim 14, wherein said impedance tuner includes a variable capacitor.

20. A substrate processing system comprising:

a deposition chamber comprising a reaction zone;

a substrate holder that positions a substrate in the reaction zone;

said substrate holder comprising a low frequency (LF) electrode;

a gas distribution system that includes a gas inlet manifold for supplying one or more process gases to said reaction zone;

said gas inlet manifold comprising a high frequency (HF) electrode;

a plasma power source for forming a plasma within the reaction zone of said deposition chamber, the plasma power source comprising a high frequency power supply coupled with the HF electrode and a low frequency power supply coupled with the LF electrode;

an impedance monitor electrically coupled to said high frequency electrode and said low frequency electrode, said impedance monitor including an impedance monitor variable capacitor;

a processor communicatively coupled to said impedance monitor for receiving as an input a measured impedance level of said plasma;

a variable capacitor electrically coupled to said LF electrode and controllably coupled to said processor wherein said processor adjusts a capacitance level of said variable capacitor to vary the impedance of said plasma in response to an output of said impedance monitor; and

a matching network coupled between a low frequency RF generator and said variable capacitor, wherein said matching network includes capacitors that are different than said variable capacitor.

23. The substrate processing system of claim 4 further comprising an RF matching network electrically coupled to the chamber, and wherein the variable capacitor is separate from the matching network.

24. The substrate processing system of claim 16 wherein the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode.

26. The substrate processing system of claim 20 wherein the impedance monitor comprises a first impedance probe connected to the HF electrode and a second impedance probe connected to the LF electrode.

27. The substrate processing system of claim 11 wherein the processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe.

28. The substrate processing system of claim 11 wherein the processor is configured to adjust at least one of a high frequency RF power level of the power source and a low frequency RF power level of the power source, based on measurements by the first impedance probe and the second impedance probe.

29. The substrate processing system of claim 13 wherein the processor is configured to adjust a setting of the impedance tuner based on measurements by the first impedance probe and the second impedance probe.

30. The substrate processing system of claim 24 wherein the computer processor is configured to adjust a pressure in the deposition chamber based on measurements by the first impedance probe and the second impedance probe.